# AERODYNAMIC STUDY OF HEAVY TRUCK USING CFD FLUENT

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Date : ……

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This report is submitted to Faculty of Mechanical Engineering in partial fulfill of the requirement of the award of Bachelor's Degree of Mechanical Engineering (Thermal-Fluid)

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"I hereby to declare that the work is my own except for summaries and quotations which have been duly acknowledge"

Signature : …….

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Date : 17TH MAY 2010

**DEDICATION**

*To him who is our source of grace, our source of commitment, and our source of knowledge,*
*And,*
*To him, whose love is a source of joy.*

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## ABSTRACT

Aerodynamic is a study about air flow around an object. In land vehicle application, aerodynamic is one of land vehicle important design after engine and suspension. A smooth design is needed to reduce air resistance to the vehicle at high speed, because air resistance will increase as the velocity increase. The Computational Fluid Dynamic (CFD) is another method to study about the air flow around the vehicle. This method was used to give the users an overview of the air flow and expected result in the aerodynamic simulation. Hence, after the experiment in the wind tunnel, the users may verify they experimental result with CFD. In this project, analysis of aerodynamic will be done on a heavy truck by using CFD-FLUENT method and wind tunnel testing. In this first part of the project, the progress was done until meshing the truck model using GAMBIT. The research is done by experimenting 2 types of model which is tri-cab design and square-cab design with 3 different angles. It is found that the tri-cab design at 30° angle give the lowest drag coefficient which is 0.55.

# ABSTRAK

Aerodinamik adalah satu kajian tentang aliran udara sekitar sesuatu objek. Di dalam aplikasi terhadap kenderaan darat, aerodinamik merupakan salah satu aspek penting terhadap kenderaan tanah selain enjin dan suspensi. Rekaan yang halus diperlukan bagi mengurangkan rintangan udara terhadap kenderaan pada kelajuan tinggi, kerana rintangan udara akan meningkat seiring dengan peningkatan halaju. *Computational Fluid Dynamic* adalah satu lagi kaedah untuk mengkaji aliran udara sekitar kenderaan. Kaedah ini biasa memberi pengguna CFD satu gambaran keseluruhan aliran udara dan jangkaan keputusan eksperimen yang akan di lakukan kelak. Oleh itu, selepas eksperimen dalam terowong angin, pengguna CFD boleh mengesahkan hasil eksperimen mereka dengan CFD. Dalam projek ini, analisis aerodinamik akan dibuat ke atas kenderaan berat dengan menggunakan kaedah CFD-FLUENT dan ujian terowong angin. Bahagian pertama di dalam projeck ini, kaedah telah dibuat sehingga penghasilan jaringan model trak menggunakan GAMBIT. Kajian ini dilakukan dengan percubaan 2 jenis model yang berbeza bentuk iaitu *tri-cab* dan *square-cab* dengan 3 sudut yang berbeza. Setelah kajian dilakukan, didapati bahawa bentuk *tri-cab* pada sudut 30° memberikan pekali seretan yang terendah iaitu 0.55.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Research Background

Aerodynamics is a branch of fluid dynamics concerned with the study of gas flows. The solution of an aerodynamic problem normally involves calculating for various properties of the flow, such as velocity, pressure, density, and temperature, as a function of space and time. Understanding the flow pattern makes it possible to calculate or approximate the forces acting on bodies in the flow.

In this recent century, vehicles were becoming faster and better. New types of research were introduced in transportation industry which is vehicle aerodynamic. Since 1914 vehicle have transform from square design into smoother design, where it improve the aerodynamic of the vehicles. The aerodynamic of road vehicle research is very important due to reduction of fuel consumption, optimize performance also to improve stability and handling in term of safety. The constant air flow are needed for better fuel economy, greater vehicle performance, reduction in wind noise level and improved road holding and stability for a vehicle on the move.

Figure 1.1: 1980 Chevrolet Corvette T-Top

*(Source: www.automagazineonline.com)*

The road vehicle aerodynamic is important for increasing the performance of the vehicle with less fuel consumption; furthermore, it also will improve stability of the vehicle. A smooth airflow around the vehicle will reduce drag on the vehicle itself, which will also reduce the engine load, as the engine load reduce, fuel consumption may reduce as well, hence giving the user the opportunity for financial saving. Other then increasing engine performance, air flow will also increase the stability of the vehicle at high speed, as the vehicle is stable at high speed the safety of the passengers were assured and the passenger may arrive at they destination in a short time.

Heavy truck is a common vehicle that people see in a highway for goods transportation. However not all people realizes that heavy truck is a blood line of economic grows where it transport goods from one point to the others. Hence by saving the maintenance cost of the truck may reduce the transportation cost, one way of reducing maintenance cost is improve the aerodynamic of the truck since truck is large and fast moving vehicle it is essential to have a good air flow around the truck to reduce engine load.

Aerodynamic characteristic is not obvious at low speed, but as the speed increase the air resistances are also increase. At this occasion more energy is needed form the engine to overcome the air resistance. The common highway speed today is at 110 km/h, to overcoming aerodynamic drag represents about 65% of the total energy expenditure for a typical heavy truck vehicle. Reduced fuel consumption for heavy vehicles can be achieved by altering truck shapes to decrease the aerodynamic resistance (drag). It is conceivable that present day truck drag coefficients might be reduced by as much as 50%.

A modern Class 7-8 tractor-trailer can weigh up to 8 tons and has a wind-averaged drag coefficient around $C_D$=0.55 to 0.80. The drag coefficient is defined as the drag/ (dynamic pressure x projected area).

Table 1.1: Range of coefficient of drag for various type of vehicle

*(Source: Barnard, R.H. [2001])*

| Vehicle type | Pre-1970 | Current | Probable near-future minimum |
|---|---|---|---|
| Medium-sized cars | 0.4–0.55 | 0.28–0.4 | 0.25 |
| Light vans | 0.4–0.6 | 0.35–0.5 | 0.3 |
| Buses | 0.5–0.9 | 0.4–0.8 | 0.3 |
| Large articulated trucks | 0.7–0.95 | 0.55–0.8 | 0.4 |
| Box truck and drawbar trailer | 0.75–1.0 | 0.7–0.9 | 0.5 |

## 1.2 Objective

The objective of this research is:

i. To study the existing heavy truck aerodynamics.
ii. To compare two roof-cap design, and study the effect to the truck.
iii. To propose a better design of roof-cap complies with good aerodynamics features.

## 1.3 Research Scope

i. Study an existing heavy truck aerodynamics specifically in Malaysia.
ii. Comparing two design of roof cab and propose the best aerodynamic features.
iii. Develop a CFD model and perform the airflow study of the heavy truck aerodynamic.
iv. Conduct a wind tunnel testing to validate the CFD simulation.

In this research, SCANIA P380 was chosen as a model for study because it is one of Malaysia most popular heavy truck. This research will focus on Computational Fluid Dynamic (CFD). Nevertheless, the validation of the CFD result will be done in the wind tunnel experiment where in this experiment further aerodynamic characteristic will be understood by the researcher. The research will be conducted using Solid work, GAMBIT and FLUENT software, where Solid work as a model builder, GAMBIT as a modeler and FLUENT as a simulator. As for experiment, wind tunnel facility will be used to investigate the aerodynamic of the truck model. The tunnel that will be used is MP 130D subsonic tunnels (Essom Company Limited).

## 1.4 Problem Statements

Initially, the author has a problem in choosing type of truck that would be the most suitable truck to be analyzed. It is found that SCANIA is the favorite heavy duty vehicle manufacturer in Malaysia not only that because it's have been here since 1971 but also the technology behind the wheel were competitive with other truck manufacturer. As we can see, SCANIA have been used for container transportation, fire fighting, cargo transport and buses.

P-130 model have been choose because it is the latest model of class 8 truck in SCANIA manufacturing industry. The model that the author will develop from solid work will not be the exact dimension with the real model; some of the truck specification will not be inserted in the truck drawing model. Specifications of the truck model that will be neglected in the solid work model is:

- Side mirror.
- Truck side doors.
- Details of the truck such as bolt nut, tires detail etc.


Figure 1.2: P-130 SCANIA Truck.

## 1.5 Project Discussion

In starting the project, expecting the worst case scenario would be the best step of doing the project, hence, several limitation have been expected to interrupt the project or change the method of the project. Limitation is problems that occur during completing this investigation and we cannot avoid it. There are a few limitations during the wind tunnel experimental test and listed as follows:

1. The maximum speed can be used of the wind tunnel approximately 30m/s or 108km/h because it is a subsonic downstream fan type.
2. Since the wind tunnel test section is a 1ft x 1ft, the wind tunnel size is not suitable for scale model within the range 1:1 to 1:10 due to blockage factor. The maximum scale model can be used for road vehicle is 1:20.

## 1.6 Significant Of The Research

The significant of this project is important for those who read this report especially for researcher in aerodynamic vehicle or people in transportation industry. This report may be useful as one of the reference for individual that working in this particular area or individual that continuing the research in heavy truck. This paper emphasizes more on how to implement an aerodynamic experiment and gathered qualitative and quantitative values. If the result of this project is better and shows some good improvement, it is better to implement the design of the roof cab to all the truck in Malaysia which will reduce operating cost or fuel consumption to generate economy development.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Literature review is about understanding the theory of the research that being done, it is considered as the most important part of research where at this part the researcher will understand the theory, then proceed with the project by referring to the theory as a guide. The information about the research theory can be found through internet thesis, journal and reference book. In this research case, all the theory or information about fundamentals of aerodynamic, vehicle aerodynamic and heavy truck aerodynamic are needed as a reference.

## 2.2 Relation between Aerodynamic and Fuel Consumption

The purpose of truck aerodynamic improvements is to minimize fuel consumption. The effect of drag reduction and fuel consumption in operation can be shown with typical vehicle in typical driving condition as in Figure 2.0.

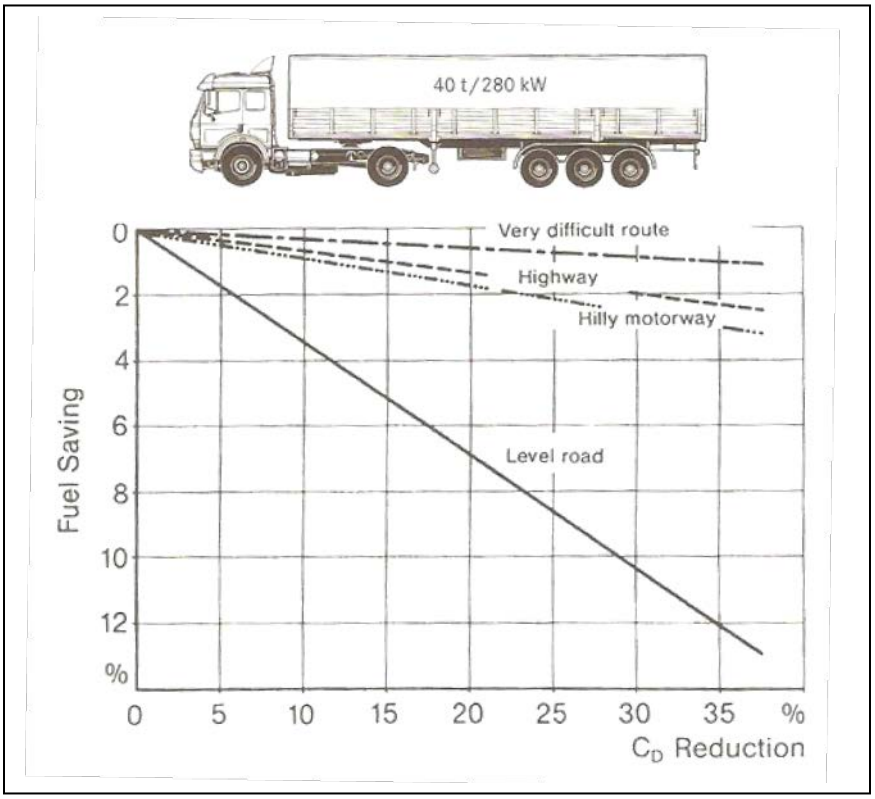


Figure 2.0: Influence of drag on fuel consumption for a tractor-trailer.

*(Source: H.Gűtz, 1982.)*

From the graph we can see that more fuel can save if coefficient of drag reduces. In other words, by improving the truck aerodynamic will reduce the drag coefficient which also reduce the engine load and save fuel. In the century where fuel source are depleting, it is essential that we reduce the usage of fuel. Since truck were use to transport goods, by reducing the fuel consumption will reduce the operating cost of the truck, hence directly will reduce the goods cost. This occasion is good for economy purposes especially for the developing country such as Malaysia.

## 2.3 Cab Shape

In truck aerodynamic improvement, cab shape plays the most important roles in reducing drag. By referring to Richard, M.W. (2003), at low speed, the mass of the truck will influence the engine load of the truck, but as the truck speeding more then 80 KM/H, aerodynamic of the truck will influence the engine load. Since in highway, trucks were speeding until approximately 100KM/H it is essential that aerodynamic improvement need to be done to reduce operating cost.

A research title Reassessment of Heavy-Duty Truck Aerodynamic Design Features done by Edwin J.S. and Robert R. Meyer, Jr, (1999) under NASA. The report describe that the aerodynamic of the truck need to be done because of the fuel crisis that hunted the transportation industry. The goal of the research is to prove that the combination of tractor-semitrailer (as shown in figure 2.1) aerodynamic configuration will reduce conventional truck coefficient of drag.


Figure 2.1: Tractor semi-trailer configuration.

*(Source: Saltzman, E.J.,1999)*